1 Introduction

1.1 Purpose

The purpose of this specification is to define the properties for cadmium-free and high transparent orange coloured glass for automotive lamp applications.

1.2 Scope

This document applies to PH474 cadmium-free orange coloured glass for automotive lamp applications.

1.3 Glass Type

PH474 cadmium-free and high transparent orange coloured glass.

1.4 Batch size

The batch size is defined as one packing unit.

1.5 Identification

The following information is given on each packing unit:

- product code number, 12 digit numerical code
- glass number
- batch identification number (lot number), including production date
- main dimensions of the product (nominal values)

In case of a customer complaint the batch numbers involved should be noted in the complaint announcement.

1.6 Packaging

All products are packed according to company packing standards. Packing instructions can be made available in English on request.

2 Product requirements

The product specification consists of 3 paragraphs, being physical properties, dimensional requirements and visual requirements.

2.1 Physical properties

	Typical	Requirement	Unit
Thermal			
Linear Expansion Coefficient (25°C - 300°C)	9.25		$*10^{-6}$/°C
Strain in 34/2		T400 +/- 100	$Nm.cm^{-1}$
Strain point	477		°C
Annealing point	512		°C
Softening point	704		°C
Working point	1019		°C
Mechanical			
Density (20 °C)	2.61		$*10^3$ kg/m^3
Optical			
CIE 1931 colour coordinate x (cured) [1]	Range available: 0.548–0.552		
T-ratio [2]	66	≥ 64.8	%

Note 1.
Thermal treatment ("curing") consists of 60 minutes in an electrical furnace at 540°C.
All measurements are normalized to 0.5 mm glass thickness. CIE 1931 colour coordinates are calculated based on a standard illuminant A light source and chromaticity standards.

Note 2.
T-ratio is the transmittance ratio of a cured sample (normalized to 0.5 mm glass thickness), calculated based on a standard illuminant A light source (CIE 1931) and chromaticity standards. This ratio is weighed for the intensity of the light source and green eye sensitivity

$$\text{T-ratio} = \int_0^\infty I(\lambda) \cdot T(\lambda) \cdot \underline{y}(\lambda)\, d\lambda \;/\; \int_0^\infty I(\lambda) \cdot \underline{y}(\lambda)\, d\lambda$$

$I(\lambda)$ = Illuminant A distribution
$T(\lambda)$ = Transmission curve
$\underline{y}(\lambda)$ = Normalized eye sensitivity for green
λ = Wavelength of light in nm

2.2 Dimensional requirements

Dimensions are according to the Product Drawing.

The dimensions of the product are checked by performing 5 measurements on each separate tube out of each sample.
This results in an inner spread, called S_0.

The variation between the tubes of the sample is called short term spread S_1.

A sample of n tubes results in the following parameters:

- X arithmetic mean
- S_1 short term spread
- S_0 *average* inner spread

2.2.1 Bow

The maximum deviation from straight of a tube compared to an ideal tube axis in 1000 mm tube length is 3 mm.

Table 1: Dimensional parameters of straight tubes (inspection by variables)

NR	Parameter	AQL	Parameter (instruction)		Means
001	Outside diameter	1.0 %	X_{avg}; S_1	[in 0.01 mm]	Measuring stand
002	Out of round	1.0 %	S_0	[in 0.01 mm]	Measuring stand
003	Wall Thickness	1.0 %	X_{avg}; S_1	[in 0.01 mm]	Measuring stand
004	Wall Thickness variation	1.0 %	S_0	[in 0.01 mm]	Measuring stand
005	Length	1.0 %	X_{avg}; S_1 (always largest value)	[in 0.01 mm]	Measuring stand
006	Skewness of cutting edge	1.0 %	S_0	[in 0.01 mm]	Measuring stand
007	Bow	1.0 %	X_{avg} (half of total indicator reading)	[in 0.01 mm]	Bow device

2.3 Visual requirements

Table 2: Class I, critical defects

NR	Defect	AQL	Description and standard	Means
101	Crack		All (other) kinds of crack	TL light source with black background.
102	Contamination		Non removable contamination	TL light source with black background.
		Total 0.4% (sum of class I defect)		

Table 3: Class II, major defects

NR	Defect	AQL	Description and standard	Means
201	Chip		Chip-off from surface not allowed, except for the edges	TL light source with black background.
202	Metal enclosure		Dark coloured enclosures in the glass. Metal particle > 0.5 mm Measure the biggest diameter of the particle.	TL light source with black background. Measuring magnifier 8x.
		Total 1% (sum of class II defect)		

Table 4: Class III, other defects

NR	Defect	AQL	Description and standard	Means
301	Damage and scratch		a. scratches (continued as well as interrupted) longer than 75mm b. scratched or damaged spot (scuff) rectangular to and totally around the tube	TL light source with black background.
302	Splinter		Internal stuck glass splinters (due to cutting of the glass)	TL light source with black background.
303	Stone & knot		White enclosure Dimension x = [length+width] / 2 - x < 0.5 mm is accepted - 0.5 < x < 1.5 mm max 1 per meter tube length - x > 1.5 mm is not accepted	TL light source with black background.
304	Cutting defect		Defined as step cut, v-chip, cascade on product drawing	TL light source with black background.
305	Breakage		Broken products in packaging	TL light source with black background.
		Total 2.5% (sum of class III defect)		

2.3.1 Airlines

The level of airlines in the glass is measured in line on a vision system (JLI). The total airline length per meter tube is determined by 100% in line measurement.

2.3.1.1 Airline level

The airline level is dependent on geometry of the product.

2.3.1.2 Airline length

The average airline length is specified in mm/m.
Default level is airline length ≤ 1800 mm/m.

2.3.1.3 Airline width

The average airline width is specified in μm.
Default level is airline width ≤ 40 μm.

3 Environmental data

3.1 Environmental declaration

Analysis Report

Number: **SW-LAB/RoHS/14-022**
Date: 04-12-2014
Company: Philips Lighting B.V.
Winschoten

Request: RoHS Certificate of Compliance Quartz Glass

RoHS Certificate of Compliance Special Glass 2014 – PH474

This document certifies that glass mentioned below are fully RoHS compliant with Directive 2002/95/EG and ISO/TS 16949.

Verification analysis are performed to establish of the following components: Pb, Cd, Hg and Cr6*.

As ICP can only establish the Cr-total content, the actual Cr6* level will be less than the reported Cr-total content.

The measured levels are (in ppm):

	Date Measured	Valid Until	Oven	Pb	Cd	Hg	Cr-total
PH474	04-12-2014	04-12-2015	SWD 7-10-14	0,19	<0,001	<3,5	1,7

< = detection limit

The maximum permitted concentrations are 0.1% or 1000 ppm (except for cadmium, which is limited to 0.01% or 100 ppm).

Philips Lighting BV
BL Quartz & Special Glass

H.P.M. Huck
Plant Manager

C. Jongeling
QA Manager

3.2 Typical chemical composition PH474 glass

Element	Weight%
SiO_2	67.76
Al_2O_3	0.03
Li_2O	1.61
Na_2O	1.79
K_2O	11.62
MgO	2.31
CaO	3.66
SrO	2.07
BaO	8.69
Fe_2O_3	0.01
MoO_3	0.064
SO_3	0.34
Rest	< 0.1

3.3 Processing instructions for high transparent amber glass (PH474)

Initially, high transparent amber glass (PH474) tubes may not fulfill the SAE or ECE colour point standards! This depends on the applied wall thickness in the bulb. In order to make the glass SAE / ECE compliant, the glass needs to be cured.
This curing process is necessary to intensify the colour of the glass and is recommended to be applied after the bulb forming.

The end colour of the amber bulbs is a function of three main parameters:

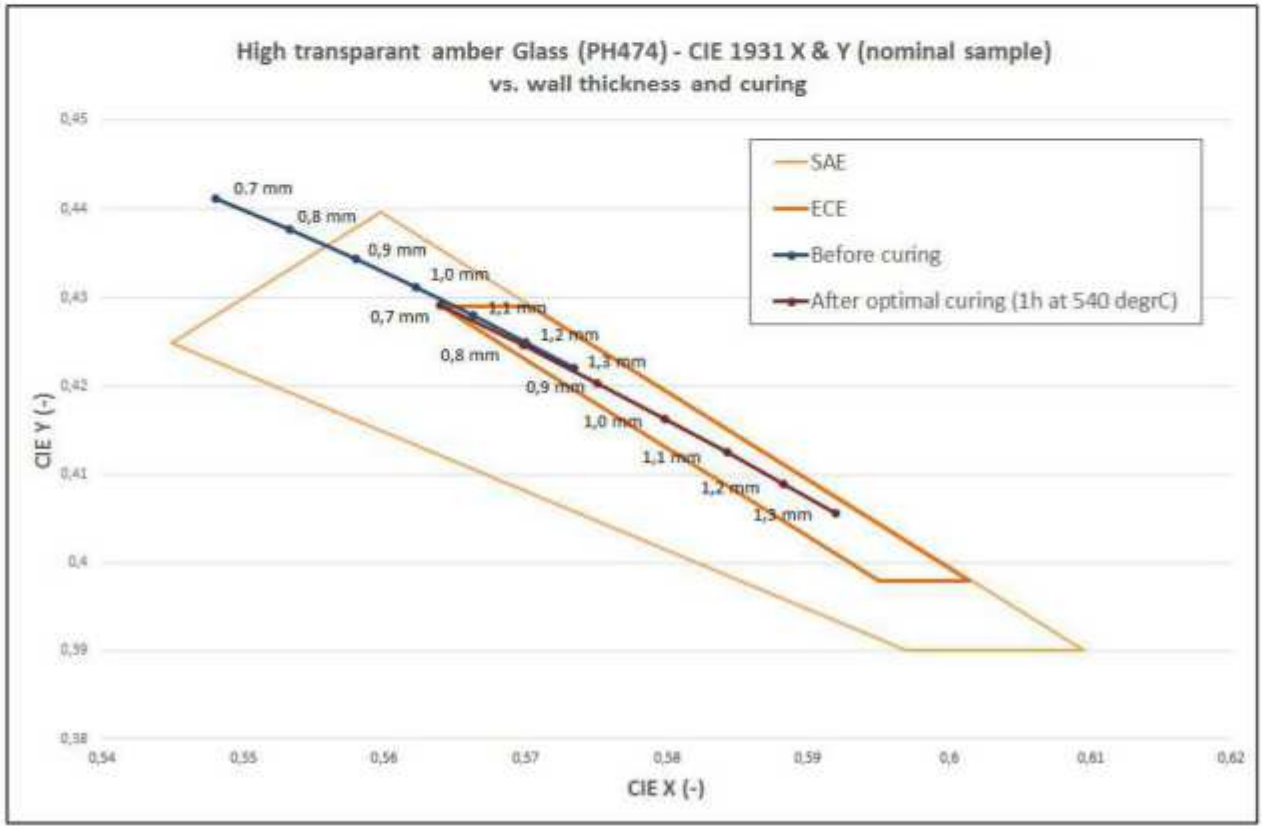
- Wall thickness of the glass in the lamp
- Curing temperature
- Curing time

It might be necessary to run a test program in order to find the right conditions for your specific amber bulb.

In order to achieve the desired colour point of the lamp, it is recommended to apply the following curing conditions:

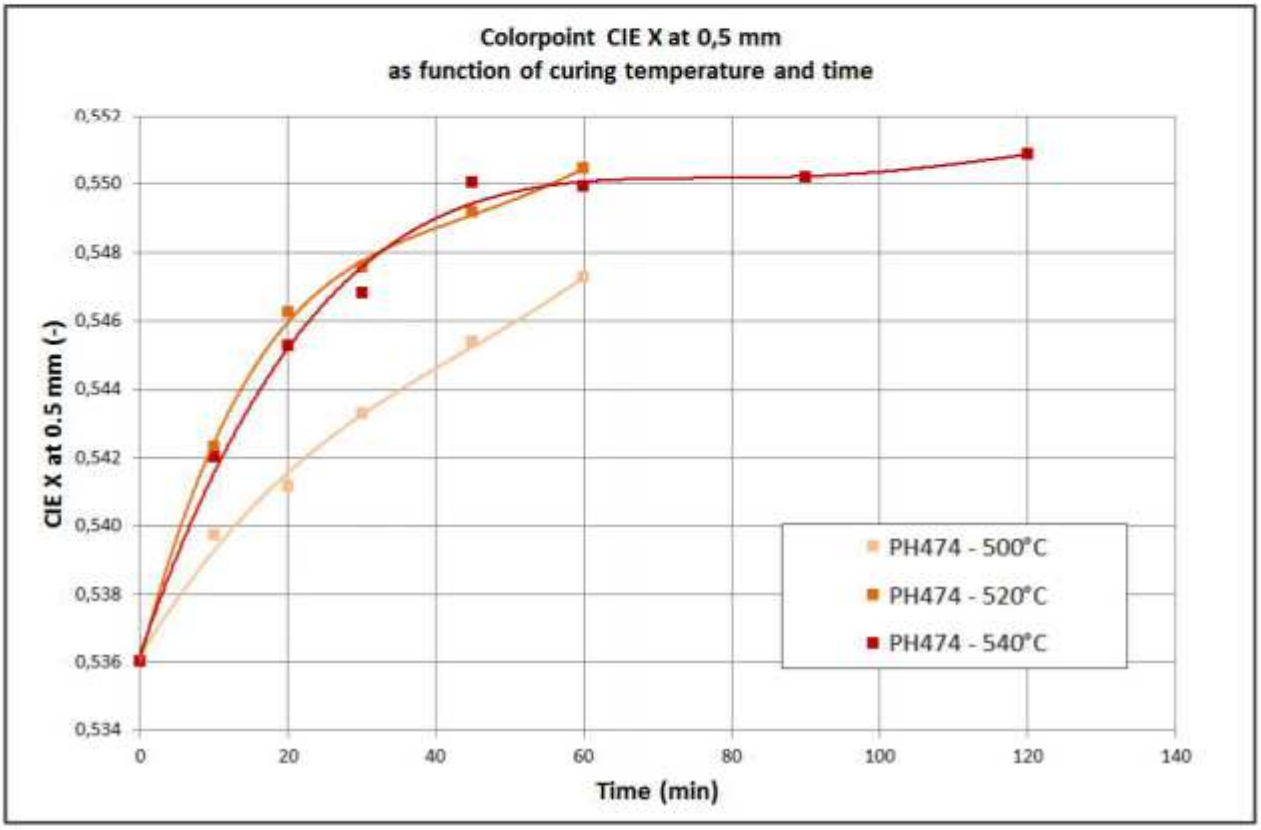
- Curing temperature: 540˚C
- Curing time: 60 minutes

Figure 1: Colour point of PH474 glass before and after optimal curing as a function of the wall thickness



In case of other curing conditions, please check the graph below in order to determine the effect of the curing conditions on the colour point (normalized at 0.5 mm wall thickness).

Figure 2: Effect of curing conditions on glass colour point CIE X



Please note that amber glass can discolour when being processed by oxidizing flames. Therefore it is advised to apply neutral / reducing flames.

Version control		
Version	**Date**	**Change**
1	07-05-2015	CP 15040. First publication.
2	15-06-2015	CP 15081. Page 2: correction of formula T-ratio.
3	08-04-2016	CP 16015. Page 2: update of T-ratio.